VLBI TRACKING OF PHOBOS-GRUNT PROBE

Guifré Molera Calvés [1,2], S.V. Pogrebenko [3], G. Cimò [3], D.A. Duev [3,4], L.I. Gurvits [3,5]

[1] Aalto University Metsähovi Radio Observatory, Metsähovintie 114 Kylmälä, FIN-02540, Finland,
E-mail: gofrito@kurp.hut.fi
[2] University of California, Berkeley, Centre for Astronomy Signal Processing and Electronics Research
[3] Joint Institute for VLBI in Europe, Dwingeloo, The Netherlands,
E-mail: pogrebenko@jive.nl, cimo@jive.nl, duev@jive.nl, lgurvits@jive.nl
[4] Moscow State University, Faculty of Physics, Moscow, Russia
[5] Delft University of Technology, DEOS - Faculty of Aerospace Engineering, Delft, The Netherlands

The Phobos Sample Return mission, also known as Phobos-Grunt, will be launched by the Russian Federal Space Agency in November 2011 and is expected to arrive to the Martian system in May 2012. The primary focus of the robotic lander is to collect a sample of the soil from the Phobos surface and return it to Earth for laboratory analysis. After the departure of the return vehicle from Phobos, the landing module will remain operational on the Phobos surface for at least a year. Being equipped with an X-band transmitter locked to the ultra-stable oscillator, it will be used as a beacon for the Planetary Radio Interferometry and Doppler Experiment (PRIDE), which will address several key scientific objectives of the mission. In particular, PRIDE-Phobos will enable characterisation of the gravitational field and geodetic parameters of the Martian moon. The European VLBI Network (EVN) radio telescopes can offer ground support for this experiment, in collaboration with the Centre for Deep Space Communication located in Ukraine.

During the last two years, as a preparatory stage for PRIDE-Phobos, several operational planetary spacecraft have been observed with the radio telescopes in Metsähovi (FI), Yebes (ES), Wettzell (DE), Onsala (SE), Matera, Medicina, Noto (IT), and Pushchino (RU). Our team has successfully conducted the Doppler and VLBI spacecraft tracking experiments with a number of deep space missions, such as the ESA's Huygens Titan Probe [1], the Smart-1 Lunar probe [2], ESA Venus Express (VEX) and Mars Express (MEX) during the Phobos-flyby [3]. During the recent years, the PRIDE group has been developing a series of scientific software tools for measurements of the Doppler-shift of the spacecraft carrier signal and accurate estimates of the spacecraft state vectors using the VLBI phase referencing technique. Observing PRIDE sessions with the VEX spacecraft were used as a test bench to optimize the technique and reduce the lag of data processing from weeks down to several hours. Rapid results are crucial for the upcoming deep space missions in view of their potential applicability for mission operations. The accuracy of the state vectors estimates depends on several parameters, of which the most important ones are the stability of the on-board oscillator and the power of the carrier signal. The SNR level of the Doppler and VLBI fringe depend on these parameters. Based on the recent experiments with the VEX and MEX spacecraft, we expect to achieve the accuracy of better than a few cm/s for the radial velocity and better than 50 m for the lateral position in the case of the Phobos-Grunt.

In this paper, we report the latest results of PRIDE observations of the VEX and MEX orbiters with the EVN radio telescopes. In these experiments we achieve a milli-Hz level of radio signal spectral resolution accuracy and extract the phase of the spacecraft carrier signal with the accuracy better than 1 radian. As a scientifically attractive by-product of these observations we present characterisation of the interplanetary plasma along the signal propagation line on various spatial and temporal scales at different solar elongation angles. These carrier signal phase fluctuations are well represented by a near-Kolmogorov spectrum. Results obtained from PRIDE observations of the VEX spacecraft so far will be used as a benchmark for the future PRIDE-Phobos observations.

REFERENCES

[1] Bird, M.K., Gurvits, L.I., Pogrebenko, S.V. et al., "*The vertical profile of winds on Titan"*, Nature, Vol. 438,8 December 2005

[2] Pogrebenko, S.V. et al., "*First results of the First EVN VLBI Practice Run on the Smart-1"*, *Presentation at Cassini, PSG meeting,* 21-23 June 2006, Nantes, France.

[3] Molera Calvés G. et al., *Venus Express spacecraft observations with EVN radio telescopes,* 7th International Planetary Probe Workshop, 12-18 June 2010, Barcelona.